INDOOR AIR QUALITY ASSESSMENT

Lunenburg Primary School
26 School Street
Lunenburg, Massachusetts

Prepared by:
Massachusetts Department of Public Health
Bureau of Environmental Health Assessment
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Background/Introduction

At the request of John Londa, Lunenburg School Department, the Bureau of Environmental Health Assessment (BEHA) was asked to provide assistance and consultation regarding indoor air quality issues and health concerns at the Lunenburg Primary School, 26 School Street, Lunenburg, Massachusetts. This request was prompted by reports of health effects that may be associated with poor indoor air quality in this building; as well as reports that smoke odors were penetrating into the building from an exterior source last winter. .

On April 4, 2000, a visit was made to this school by Michael Feeney, Chief of Emergency Response/Indoor Air Quality (ER/IAQ), BEHA, to conduct an indoor air quality assessment. Mr. Feeney was accompanied by Mr. Londa. The school is a one and a half-story red brick building, built in 1910; the basement level being partially above ground. The roof over the main building consists of shingles on the peaked roof and a rubber membrane roof over the gymnasium. The first floor and basement contain general classrooms. Restrooms and the gymnasium are located at the basement level. A boiler room is located several feet below basement level near the center of the building.

During the mid-1970's, the building was renovated. A new furnace was installed with major alterations done to the heating, ventilating and air-conditioning (HVAC) system. Energy efficient exterior windows were also installed in the building.

Methods

Air tests for carbon dioxide were taken with the Telaire, Carbon Dioxide Monitor and tests for temperature and relative humidity were taken with the Mannix, TH Pen PTH8708 Thermo-Hygrometer.

Results

This school has a population of 178 pre-kindergarten and kindergarten students and a staff of approximately 10. The tests were taken under normal operating conditions. Test results appear in Tables 1-2.

Discussion

Ventilation

It can be seen from the tables that carbon dioxide levels were elevated above 800 parts million of air (ppm) in 10 of the 12 classrooms surveyed, which is indicative of an overall ventilation problem in this school. Of note was classroom 5 that had levels of carbon dioxide in excess of 2,000 ppm with the room occupancy doubled. This building does not have a modern mechanical ventilation system.

The building was originally equipped with a gravity/natural ventilation system to provide airflow to classrooms in combination with openable windows. An examination of the building revealed that the original ventilation system was renovated out of existence, presumably by the 1970's renovations. Ventilation was provided by a series of louvered vents. Each classroom has an approximately 3' x 3' grated air vent in the center of an interior wall near the ceiling, which was connected by an airshaft to the school boiler. A corresponding 3' x 3' vent exists in each room that was connected to an exhaust ventilation shaft that extends from each first floor classroom to the cupolas located on the roof (see Picture 1). No exhaust vents exist in the basement classrooms. Two exhaust vents were observed in the basement hallway, but were sealed. The building has two of these shafts on either side. Classrooms were constructed around these shafts to provide exhaust ventilation.

Air movement is provided by the stack effect. The heating elements warm the air, which rises up the fresh air ventilation shafts. As the heated air rises, negative pressure is created, which draws cold air from outdoors into an air mixing room in the basement area into the heating elements. This system was designed to draw fresh air from a hinged window-pulley system on the exterior wall of the building. These sources of air mix in the basement prior to being drawn into the heating elements. The amount of fresh air drawn into the air mixing room was controlled by the hinged window-pulley system. The chains of the pulley system were set to lock the hinged window at a desired angle to limit fresh air intake. Fresh air in winter is supplied throughout the building by air vents.

Exhaust ventilation is provided by the exhaust vents in each classroom and the basement. Heating elements in the exhaust vents heat air. Negative pressure is created in these shafts, which in turn draws air into the cool air vents of each classroom. The draw of air into these exhaust air vents is controlled by a draw chain pulley system. Air rises up the ventilation shaft to exhaust outdoors through openings shielded by the rooftop cupolas.

As noted previously, it appears that the fresh air supply for the gravity feed ventilation system was renovated out of existence. Fresh air vents in classrooms were sealed with wall plaster (see Picture 2). Classroom closets appeared to be installed in the airshafts. Air mixing rooms on both sides of the building were dismantled. The ceilings of both corner basement classrooms have outlines where former air mixing room walls existed (see Picture 3). The windows formerly used as fresh air intakes were replaced with energy efficient windows. These renovations effectively rendered the fresh air supply for these vents inoperable and unrestoreable. The only source of fresh air in classrooms is openable windows.

Exhaust vents in first floor classrooms were concealed behind cabinets (see Pictures 4 and 5). Basement exhaust vent airshafts were sealed with plywood (see Picture 6).

The control mechanisms within this natural ventilation system are nonfunctional. In a number of classrooms, the chain pulley, louver door systems are removed. The exhaust vents on the first floor have been sealed with wood plugs (see Picture 7).

The Massachusetts Building Code requires a minimum mechanical ventilation rate of 15 cubic feet per minute (cfm) per occupant of fresh outside air or have openable windows in each room (BOCA, 1993, SBBRS, 1997). The ventilation must be on at all times that the room is occupied. Providing adequate fresh air ventilation with open windows and maintaining the temperature in the comfort range during the cold weather season is impractical. Mechanical ventilation is usually required to provide adequate fresh air ventilation.

Carbon dioxide is not a problem in and of itself. It is used as an indicator of the adequacy of the fresh air ventilation. As carbon dioxide levels rise, it indicates that the ventilating system is malfunctioning or the design occupancy of the room is being exceeded. When this happens a buildup of common indoor air pollutants can occur, leading to discomfort or health complaints. The Occupational Safety and Health Administration (OSHA) standard for carbon dioxide is 5,000 parts per million parts of air (ppm). Workers may be exposed to this level for 40 hours/week based on a time-weighted average (OSHA, 1997).

The Department of Public Health uses a guideline of 800 ppm for publicly occupied buildings. A guideline of 600 ppm or less is preferred in schools due to the fact that the majority of occupants are young and considered to be a more sensitive population in the evaluation of environmental health status. Inadequate ventilation and/or elevated temperatures are major causes of complaints such as respiratory, eye, nose and throat irritation, lethargy and headaches.

Temperature readings ranged from 67^0F to $76\,^0$F, which was slightly below the BEHA's recommended comfort guidelines. The BEHA recommends that indoor air temperatures be maintained in a range of $70\,^0$F to $78\,^0$F in order to provide for the comfort of building occupants. In many cases concerning indoor air quality, fluctuations of temperature in occupied spaces are typically experienced, even in a building with an adequate fresh air supply.

The relative humidity in this building was within the BEHA recommended comfort range in most areas sampled. Relative humidity measurements ranged from 38 to 55 percent. The BEHA recommends that indoor air relative humidity is comfortable in a range of 40 to 60 percent. Relative humidity levels in the building would be expected to drop during the winter months due to heating. The sensation of dryness and irritation is common in a low relative humidity environment. Low relative humidity is a common problem during the heating season in the northeast part of the United States.

Moisture/Microbial Concerns

A water-bubbler was located near Room 2 over carpeting. Use of this water bubbler can result in repeated water damage to this carpet, which may result in mold growth. The American Conference of Governmental Industrial Hygienists (ACGIH) recommends that carpeting be dried with fans and heating within 24 hours of becoming wet (ACGIH, 1989). If carpets are not dried within this time frame, mold growth may occur. Water-damaged carpeting cannot be adequately cleaned to remove mold growth.

Classroom 1 contained a fish tank of an opaque green color, which may be algae growth. Algae growth can result in nuisance odors that can be irritating to the respiratory system in sensitive individuals.

Other Concerns

As reported by Mr. Londa, smoke odors were reported in the building. The most likely pathway for exterior smoke odors is through the former exhaust vent system. These odors may be attributed to the entrainment of wood-stove smoke from neighboring homes. On cold weather days, cold air can backdraft through the exhaust vents. Outdoor pollutants may accompany this air movement.

Restrooms had local mechanical exhaust ventilation. The original restroom exhaust ventilation system for both rooms appears to be dismantled (see Picture 8). The girl's restroom has a window-mounted fan, but a curtain blocks the vent, which degrades airflow (see Picture 9). Exhaust ventilation is necessary to prevent restroom odors from penetrating into occupied areas in the basement.

Conclusions/Recommendations

The renovations of this building have altered the original design of the ventilation system. Therefore, it appears that the restoration of this system would be impossible due to the removal of the air mixing rooms in the basement and placement of closets in the original ventilation shafts. In this particular case, the only form of ventilation available within classrooms is openable windows. Without a restorable ventilation system, a two-phase approach is required, consisting of immediate measures **(short-term)** to improve air quality at the school and **long-term** measures that will require planning and resources to adequately address overall indoor air quality concerns within this building.

Short Term Recommendations

1. Since the renovations rendered the exhaust ventilation shafts obsolete, the opening of the exhaust vents on the rooftop cupolas should be sealed to prevent odor and/or

air penetration into the interior of the building. Seal any remaining exhaust vent shaft openings in classrooms.

2. Use windows to provide ventilation in classrooms. Care should be taken to close windows at the end of the day to prevent water damage and pipes from freezing during cold weather.
3. For buildings in New England, periods of low relative humidity during the winter are often unavoidable. Therefore, scrupulous cleaning practices should be adopted to minimize common indoor air contaminants whose irritant effects can be enhanced when relative humidity is low. Drinking water during the day can help ease some symptoms associated with a dry environment (throat and sinus irritations). Consider using a vacuum cleaner equipped with a high efficiency particulate arrestance (HEPA) filter to reduce the aerosolization of respirable dusts.
4. Restore the exhaust ventilation system for the boy's room in the basement.
5. Examine carpet beneath water cooler for mold growth. If carpeting is moldy, discard. Consider replacing carpeting underneath the water cooler with tile or water impermeable surface to prevent moistening of the carpet.
6. Maintain aquariums to prevent mold/algae growth.
7. Consider using charcoal filters in univents of classrooms that have a reported history of wood stove odors from neighboring houses during the heating season.

Long Term Recommendations

Without a ventilation system, control of fresh air supply is difficult. This is a problem that may require renovation or refurbishing of equipment.

1. Consider consulting a ventilation-engineering consultant to examine options for the installation of a mechanical ventilation system in classrooms.

References

ACGIH. 1989. Guidelines for the Assessment of Bioaerosols in the Indoor Environment. American Conference of Governmental Industrial Hygienists, Cincinnati, OH.

BOCA. 1993. The BOCA National Mechanical Code-1993. 8th ed. Building Officials & Code Administrators International, Inc., Country Club Hills, IL. M-308.1

OSHA. 1997. Limits for Air Contaminants. Occupational Safety and Health Administration. Code of Federal Regulations. 29 C.F.R 1910.1000 Table Z-1-A.

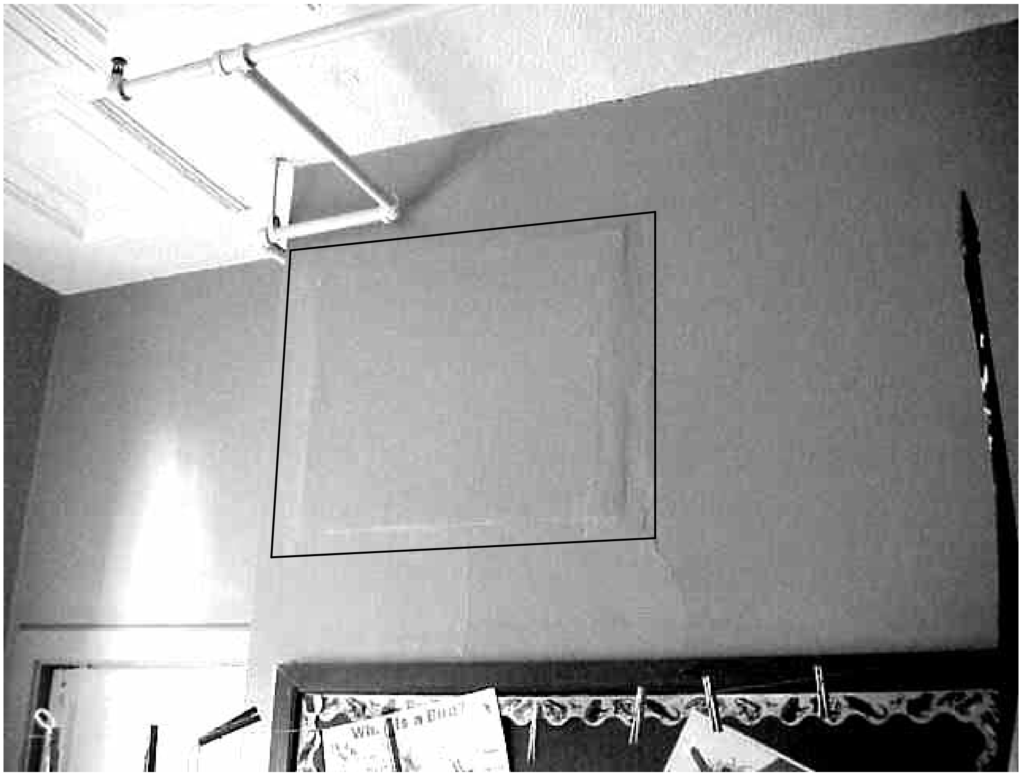
SBBRS. 1997. Mechanical Ventilation. State Board of Building Regulations and Standards. Code of Massachusetts Regulations. 780 CMR 1209.0

Picture 1

Exhaust Vent Cupolas

Rooftop Cupolas that Cover Exhaust Vents of the Gravity Ventilation System

Picture 2



Fresh Air Supply Vent Sealed with Plaster (Lines Added to Outline Sealed Vent)

Picture 3

Former Ceiling/Air Mixing Room Wall Junction

Basement Classroom That Formerly Contained an Air Mixing Room, Note the Outline in the Ceiling and Closet Installed in Airshaft

Picture 4

Exhaust Vent

Exhaust Vent Concealed by Cabinet

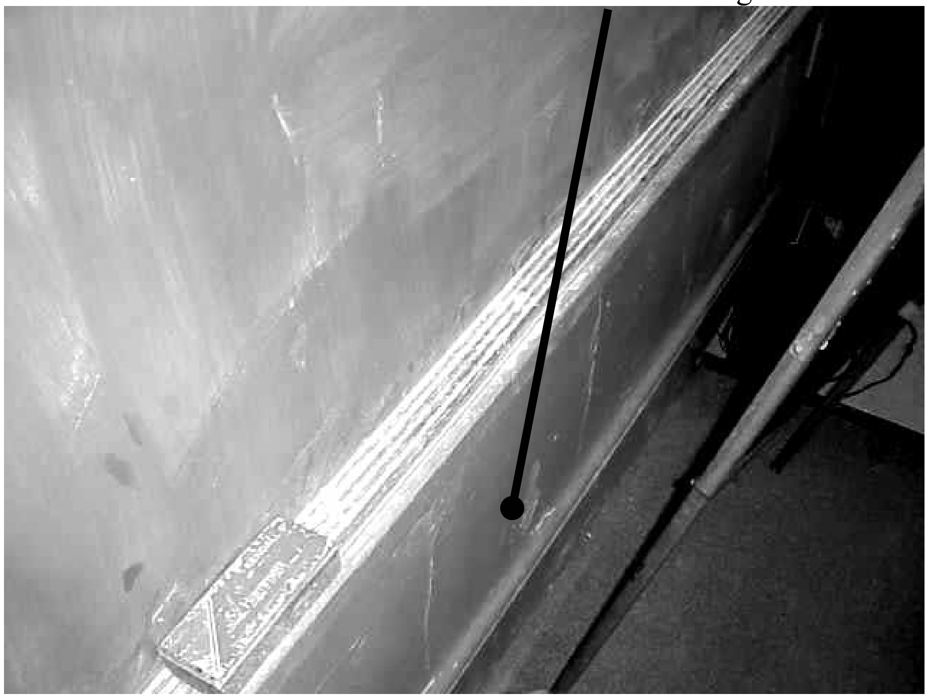
Picture 5

Close-Up of Blocked Exhaust Vent in Picture 5, Note the Accumulation of Dust That Indicates Airflow into this Vent

Picture 6

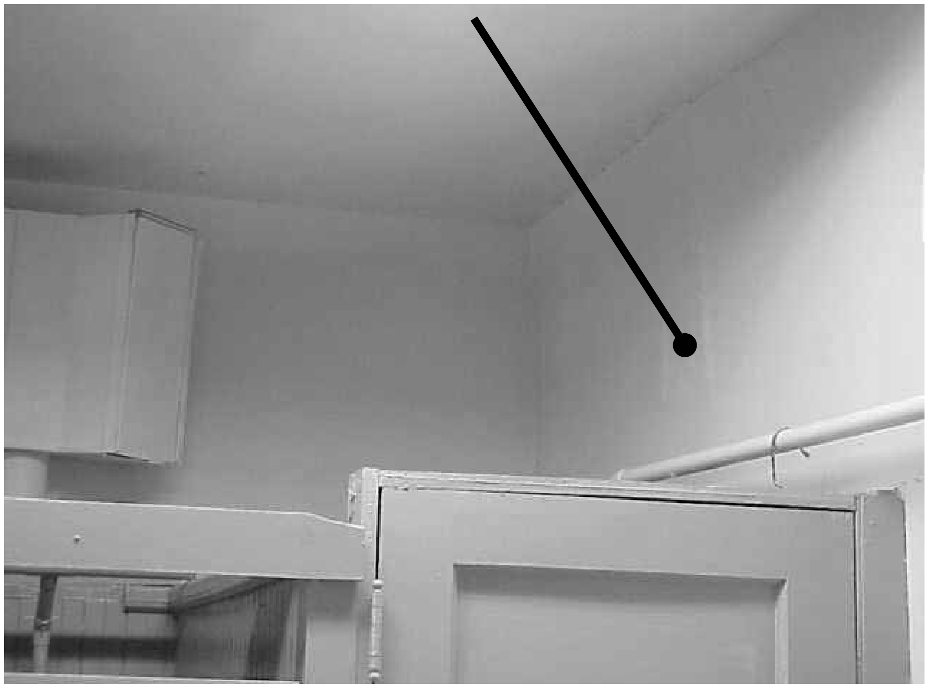
Sealed Basement Exhaust Vent, Note Pull Chain above Vent

Picture 7



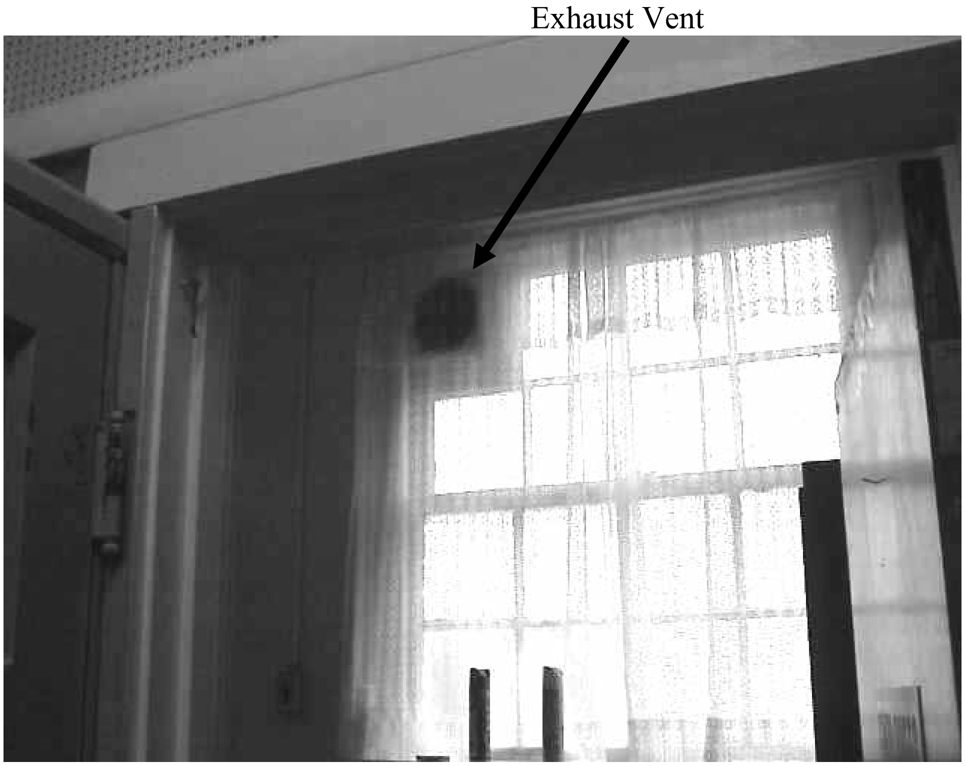
Sealed Classroom Exhaust Vent

Picture 8



Disconnected Boy's Restroom Exhaust Vent, Note Sealed Wall Hole Formerly Used for Ductwork

Picture 9



Girl's Restroom Exhaust Vent Blocked by Curtain

TABLE 1

Indoor Air Test Results – Lunenburg Primary School, Lunenburg, MA – April 4, 2000

Remarks	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
						Intake	Exhaust	
Outside (Background)	414	65	62					
Gym	898	71	44	0	no	no	no	
Krysiak Room	631	73	47	2	yes	no	no	window open
Small Office Basement West	764	73	41	0	yes	no	no	
Horrigan Room	933	67	55	0	yes	no	no	
Boy's Restroom						no	yes	
Crawley Room	1148	70	41	6	yes	no	no	
Girl's Restroom						no	yes	
Martin Room	1124	74	44	4	yes	no	no	
Room 6	1672	74	45	0	yes	no	no	door open
Room 5	2000+	74	51	44	yes	no	no	door open

*** ppm = parts per million parts of air**
CT = water-damaged ceiling tiles

Comfort Guidelines

Carbon Dioxide -	< 600 ppm = preferred
	600 - 800 ppm = acceptable
	> 800 ppm = indicative of ventilation problems
Temperature -	70 - 78 °F
Relative Humidity -	40 - 60%

TABLE 2

Indoor Air Test Results – Lunenburg Primary School, Lunenburg, MA – April 4, 2000

Remarks	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
						Intake	Exhaust	
Room 4	1181	76	51	3	yes	no	yes	exhaust blocked, window and door open
Room 3	1431	76	38	2	yes	no	no	
Room 2	1324	75	42	6	yes	no	no	water fountain on carpet, door open
Room 1	1318	73	40	3	yes	no	no	fish tank-algae

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